



Irrigated Lands Program Crop Nitrogen Removal Conversion Coefficient Standard Protocols

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What is a crop nitrogen removal conversion coefficient?

The [Agricultural Order](#)¹ includes crop nitrogen removal conversion coefficients (crop conversion coefficient) for crops grown representing 93% of all crop acres in the central coast region. University of California Cooperative Extension (UCCE) researchers are currently working on developing crop conversion coefficients for additional crops. This effort will increase the crop conversion coefficient coverage to approximately 97% of all crop acres in the central coast region. This work will be finalized in December 2023.

The crop conversion coefficient is the nitrogen content in the fresh weight of the crop material. The crop conversion coefficient multiplied by the weight of the crop material removed from the field is used to calculate the nitrogen removed from the field through harvest or other removal of crop material methods (R_{HARV} ^{2, 3}).

$$R_{HARV} = \text{Crop Conversion Coefficient} \times \text{Crop Material Removed}$$

- R_{HARV} is the amount of nitrogen removed from the field through harvest or other removal of crop material.
- **Crop Conversion Coefficient** is a crop-specific coefficient used to convert from units of material removed per acre to units of nitrogen removed per acre.
- **Crop Material Removed** is the amount of nitrogen-containing material removed from the field, in units of pounds per acre.⁴ The crop material removed in pounds must be determined by growers and/or consultants by weighing the fresh harvested material or employing other methods⁵ and information generated during harvest.⁶

¹ Agricultural Order No. R3-2021-0040

https://www.waterboards.ca.gov/centralcoast/water_issues/programs/ilp/regulatory_information.html

² Agricultural Order, Page 26, Paragraph 14

https://www.waterboards.ca.gov/centralcoast/water_issues/programs/ilp/docs/ag_order4/2021/ao4_order.pdf

³ Agricultural Order, Attachment B – MRP, Page 8-9, Paragraph 16

https://www.waterboards.ca.gov/centralcoast/water_issues/programs/ilp/docs/ag_order4/2021/ao4_att_b.pdf

⁴ For crops packed in field and for crops removed as “boxes”, a protocol will need to be implemented for averaging the weights of the crop material removed in the boxes or packing units.

⁵ Growers with crops in pots, trays, and plants produced in any other type of containerized production, such as nurseries and greenhouses, will need to develop a methodology to consistently estimate the average weight of plant material removed in units of pounds per acre for reporting purposes. In addition, containerized production systems usually remove soil and/or media (such as peat and perlite growth media) inside pots or trays along with the plants that are harvested. If that is the case, the amount of nitrogen present in the soil and/or soil media should be accounted for as a form of nitrogen removed.

⁶ To calculate an accurate crop nitrogen conversion coefficient and the amount removed from the fields, the weight (pounds) of the crop material tossed out (culls) at a packing facility needs to be accounted for.

What crop conversion coefficient should I use?

Growers must either use a crop conversion coefficient provided by the Central Coast Water Board in the Monitoring and Reporting Program for the Agricultural Order (see [Table MRP-4](#)⁷) or develop and use their own crop conversion coefficient. For crops that do not yet have approved crop conversion coefficients, growers must either select a crop conversion coefficient from Table MRP-4 for a crop that is similar to their crop or develop their own crop conversion coefficient. Growers who elect to develop their own crop conversion coefficient must do so by obtaining a laboratory result from samples collected from their own or similar crop and fields, following the standard protocols described in the remainder of this document. Growers must maintain any data collected and rationale used in determining their individual crop conversion coefficient in the Farm Plan. This information must be submitted to the Central Coast Water Board upon request.

There are three (3) options to determine what crop conversion coefficient to use:

1. **Select a crop conversion coefficient provided in [Table MRP-4](#).**
2. **Select a crop conversion coefficient provided in [Table MRP-4](#) for a crop that is similar to the crop being grown** (e.g., similar characteristics, growing stages, and nitrogen uptake amount). For example, the crop conversion coefficient for one type of lettuce may be representative of a different type of lettuce.
3. **Develop and use your own crop conversion coefficient following the standard protocols described in this document.** Refer to the section in this document titled, “What are the standard protocols to develop a crop conversion coefficient?”

What are the standard protocols to develop a crop conversion coefficient?

This section includes the standard protocols that must be followed to develop a crop conversion coefficient. These standard protocols were developed in coordination with UCCE researchers, qualified professionals, and laboratories, and were made available to California Department of Food and Agriculture (CDFA) for review and comment.

There are two values that must be determined to develop a crop conversion coefficient:

1. Crop dry matter content (%), and
2. Crop nitrogen content (%).

⁷ Agricultural Order, Attachment B, Table MRP-4, Page 36

https://www.waterboards.ca.gov/centralcoast/water_issues/programs/ilp/docs/ag_order4/2021/ao4_att_b.pdf

The following formula is used to calculate the crop conversion coefficient:

$$\text{Crop Conversion Coefficient} = (\% \text{ dry matter content} \times \% \text{ nitrogen content}) \div 10,000$$

1. Determine crop dry matter content of the harvested material (**% dry matter content**)

The dry matter content is determined by weighing a sample of the fresh/wet harvested material (to determine “wet weight”) and reweighing it after the same sample is thoroughly dried (to determine “dry weight”). The results can be used to calculate the percent of dry matter content using the following formula.

$$\% \text{ dry matter content} = (\text{dry weight, lab measurement} \div \text{wet weight, field/site measurement}) \times 100$$

These standard protocols outline two methods to measure the dry weight. For each method the field sampling protocols remain the same and are described below.

2. Determine crop nitrogen content of the harvested material (**% nitrogen content**)

The % nitrogen content is analyzed by the laboratory in the dried sample and represents the percent of nitrogen content in the dry matter of the harvested material.

Lab results for nitrogen content of the sample are provided on a dry weight basis. This value along with the percent dry matter (calculated by measuring the wet and oven dry weight of the sample) are used to calculate the crop conversion coefficient. Most laboratories will provide both the % dry matter⁸ and the % nitrogen content in dry matter.

3. Calculate the crop conversion coefficient

Example crop conversion coefficient calculation when laboratory reports both the % dry matter content and the % nitrogen content:

$$\text{Reported \% dry matter content} = 4.7\%$$

$$\text{Reported \% nitrogen content} = 3.5\%$$

$$\begin{aligned} \text{Crop conversion coefficient} &= (4.7\% \text{ dry matter content} \times 3.5\% \text{ nitrogen content}) \div 10,000 \\ &= 0.001645 \end{aligned}$$

⁸ If the laboratory report includes the % moisture content instead of the % dry matter, the % dry matter can be calculated as follows: % dry matter = 100 – % moisture content.

Field Sampling Protocols

Before any samples are collected, follow steps one and two below:

1. Select a laboratory from the list provided by the Central Coast Water Board.⁹ Contact the laboratory ahead of time to confirm availability and ensure they have established protocols to measure both the % dry matter content and the % nitrogen content of the plant sample in a timely manner.
2. Confirm and/or obtain from the laboratory any material necessary to prepare the samples for shipping, such as plastic or paper bags, markers to label the bags, a neatly organized data sheet to record sample information (and fresh weights for Method 2 samples), and a sample chain of custody form.

Next, follow the procedures below to provide the laboratory with a sample. The laboratory only analyzes a small sample of plant material. Therefore, the first step when collecting a sample is to obtain a manageable quantity (or manageable sample size) of a representative crop field sample of the harvested crop material. A representative crop field sample is a small quantity (subset) of material that reflects the same properties that exist in a larger population of the harvested material from a field or crop. To obtain a representative crop field sample to send to the laboratory for analysis, follow the guidelines listed below:

3. Collect samples of the crop “at harvest”¹⁰, not before or after harvest¹¹, to ensure a representative sample of the harvested materials. The nitrogen concentration in the harvested crop is a cumulative value of the amount absorbed during the entire crop growing cycle. In situations when the harvest period extends for multiple weeks, an average nitrogen crop conversion coefficient will need to be calculated using nitrogen crop conversion coefficients calculated for the harvested material collected at the beginning, middle, and end of the harvest period. Calculation of an average nitrogen crop conversion coefficient is particularly important in situations where the crop is planted in blocks with different planting dates and therefore different harvest dates, and for crops with harvest periods that extend over many months. In all cases, the company, laboratory, consultant, or the grower who is taking the samples, must complete and maintain all information related to the sampling event(s), such as a

⁹ Includes labs that have a certification or participate in the North American Proficiency Testing, [NAPT Program](#) (coordinated by the Soil Science Society of America) or in the Dr. Robert Miller's Agriculture Laboratory Proficiency program, administered in conjunction with the [Collaborative Testing Services, Inc.](#)

¹⁰ Crop is “at harvest” when the grower has decided to harvest and when the harvesting crews are harvesting the field. In the case of containerized production, samples must be taken prior to the shipping or sales of the plants/product.

¹¹ The only exception is for crops that must be sampled from the packing facility. See section below on collecting a sample from the packing facility

sampling map, locations, sampler information, sampling date and protocols, number of samples taken, etc.

4. Either sample a typical area¹² that is representative of the crop field, or sample portions of the crop material harvested from multiple areas of the field (i.e., from at least 4 or more locations).¹³ Combine (i.e., composite) the multiple samples or subsamples into a single sample for laboratory analysis.
5. The sample must include all plant parts that are typically removed from the fields (or shipped, in containerized production). If other crop materials are removed at other times of the year (e.g., the removal of pruning's), they must be sampled separately so that nitrogen removed in those tissues are also included in the calculated crop conversion coefficient. Collect pruning samples from multiple areas of the field.
6. The sample should be free from soil or other contamination that could influence the sample weight or nitrogen content. Shake to remove any soil and/or wipe it off.
7. Sample enough plant material so that a representative subsample can be taken from the total sample. For example, less material may be needed for a grain crop that has been through a harvester than for a watermelon crop, due to the different harvest methods and relative size of the individual grains and watermelons.
8. Subsampling is commonly required to reduce the size of the sample to a manageable sample size. For example, in the case of lettuce, the entire sample might include 10 or more heads, which is too much material to send to the laboratory. To properly subsample a head of lettuce, cut the sample vertically to assure that the sample represents all the tissues (older and younger) in the head.¹⁴ After cutting the heads, mix the entire lot of sampled material, and draw slices of the heads at random from the mixture until you have a manageable sample size to submit to the laboratory.
9. Once the samples or subsamples are ready, determine the fresh/wet and dry weights by following one of two methods described below.
10. Under any method, if the sample is perishable, and to prevent spoilage and processes that will alter the original amount of nitrogen removed from the field,

¹² In the case of containerized production, a typical area refers to a bench or outdoor production area (in square feet). The typical area must be representative of different containers, plant trays, pots, etc.

¹³ General guidelines developed to measure the nitrogen (N) content in plant tissue specify a minimum of 20 leaves.

¹⁴ In crops where multiple tissues/parts are harvested, each tissue/part needs to be proportionally represented as part of the complete sample. In cases where the parts cannot be mixed and sampled proportionally and/or cannot be analyzed together (perhaps due to differences in texture, such as woody and fleshy plant parts), subdivide the samples, and process disparate parts separately. Afterward, the contributions of the parts to fresh weight (wet weight) and percent N content can be calculated.

samples/subsamples must be protected from external moisture, internal moisture loss, and contamination until delivered to a qualified laboratory.

11. In some instances, such as wheat or seed crops, where the moisture content is measured and known at the time of harvest, growers must submit samples to the laboratory in accordance with either Method 1 or 2 below and provide the moisture content.

Packing Facility Sampling Protocols (Alternative to Field Sampling)

In some instances, samples can be obtained from packing facilities, where harvests are frequently sampled to determine crop quality, as long as the sample is taken the same day the fields are harvested. Samples may be obtained at processing facilities if the sample is representative of the crop in the fields, as described in the field sampling protocols above. However, some moisture loss will occur and result in proportional increases in the percent nitrogen in the sample. To minimize moisture loss, samples must be prepared as soon as possible.

Methods to Prepare Samples for Laboratory Analyses

<i>Method 1: Field fresh/wet and Laboratory dry weight of the samples/subsamples:</i>

The fresh/wet weight of the harvested sample is measured at the field site before water loss occurs and to ensure an accurate measurement of the fresh moisture content of the product.

- a. Confirm who will be weighing the samples/subsamples in the field to obtain the fresh/wet weight.
- b. This procedure requires the use of a calibrated scale with accuracy of 0.1 grams.
- c. Record the fresh/wet weight of the sample/subsamples in the field and provide that measurement(s) to the laboratory along with the samples.
 - a. Growers/consultants or individuals weighing the samples/subsamples in the field must provide the fresh weight value and its corresponding units (grams, pounds, etc.) information for the laboratory to calculate the dry matter content.
- d. Samples can then be placed into bags (provided by the laboratory) and delivered (or shipped) to the laboratory. The laboratory will determine the dry weight of the samples (excluding the weight of the bag).

Method 2: Field fresh/wet and dry weight of the samples/subsamples:

Follow steps a-c in method 1 above to obtain the fresh/wet weight of the harvested sample/subsample at the field site before water loss occurs and to ensure an accurate measurement of the fresh moisture content of the product.

This procedure requires the use of a convection drying oven. It also requires receptacles to hold plant parts during processing, and tools (e.g., knives, food processors, mills) to prepare the samples for analysis.

- e. Place samples into bags and bring into the office or field laboratory.
- f. Upon return to the office or field laboratory, samples are placed in a convection drying oven (without the bag) at 60 degrees Celsius (°C; or 140 °F) for 48 hours, or until the samples are completely dry. After the initial drying period, samples should be removed, weighed, and returned to the ovens for another period of drying. No less than 24 additional hours. The samples should be crispy when thoroughly dried. If still rubbery, they may need an additional 12 to 24 hours of drying time. Drying plant material could take several days for some harvested materials, some crops may require grinding of harvested material before drying (e.g., carrots). After the secondary drying period, remove samples from the oven and re-weigh. Drying is complete if the % change of dry material weight is <5%. Calculate the percent change of dry material weight using the formula below:

$$\% \text{ change of dry material weight} = [(\text{initial dry weight} - \text{secondary dry weight}) \div \text{initial dry weight}] \times 100$$

- g. The net weight of the oven dried samples (dry weight) needs to be measured immediately after taking the samples from the oven to avoid rehydration (the dry tissue absorbs moisture from the air quickly). The dry weight is the weight without the paper bag.
- h. The percent dry matter content of the samples will be calculated from the fresh/wet weight and the dry weight of the harvest samples using the following formula.

$$\% \text{ dry matter content} = (\text{dry weight, lab measurement} \div \text{wet weight, field/site measurement}) \times 100$$

- i. Dried samples can then be stored at room temperature in bags (may be provided by the laboratory) until they are delivered to a laboratory to determine total nitrogen content. Inform the laboratory of the amount of time the dried samples were stored in the bag before delivery to the laboratory, as the nitrogen content result will be affected by re-hydration and the samples may need to be re-dried at the laboratory to obtain an accurate measurement of the nitrogen content.

How do I report my crop conversion coefficient(s)?

The crop conversion coefficient(s) are reported as part of your ranch Irrigation and Nutrient Management Plan (INMP) Summary Report. It is anticipated that the INMP Summary Report form will be available in GeoTracker in late 2022. Additional information and details will be provided about the INMP Summary Report in late 2022.

What records do I need to maintain in the Farm Plan?

Records, methods used, and all pertinent information must be maintained in your Farm Plan. At a minimum the records must include all the results, information, and communications from the laboratory who performed the analysis, the chain of custody documenting all the samples submitted to the laboratories, a list of all the field sampling protocols to measure the fresh/wet weight and % dry matter content under methods 1 and 2 listed above, crop, location, and timing of the sampling.

When requested, all records related to the determination of the crop conversion coefficients must be submitted to the Central Coast Water Board.

Laboratory Analysis Guidance

1. The laboratories must provide the % dry matter content and the % nitrogen content in the dry matter. Laboratories must maintain a chain of custody.
2. The recommended methodology to measure the nitrogen content is the standard dry combustion method, or the dry method.^{15,16} The standard dry combustion method (Dumas) is recommended because it accounts for all the different chemical or molecular forms of nitrogen and the analysis is quick, only about six minutes.
3. If the laboratory must dry sugary products, sugary fruits, oil products, pitted fruits, and other types of tissues, consider the following: Pits must be sampled separately. For sugary fruits/materials the plant material is typically blended and then freeze dried (they cannot be directly dried, so they are first ground into a pulp using a blender or food processor, and then the pulp is dried). The oily materials can't be ground directly because the oil adheres to the blade; instead, they are course ground, and cellulose powder (no nitrogen contained) is added at a 1:1 ratio to soak up the oil and then the

¹⁵ Information about the dry method can be found at the [University of California Analytical Lab Website](#). The other common method is the Total Kjeldahl Nitrogen (TKN) method, but the nitrogen present as nitrite (NO²) and nitrate (NO³) forms need to be added at the end of the process, since only organic and ammonia (NH⁴) nitrogen are only measured via the TKN method.

¹⁶ Consider using the LECO CN928 analyzer. It is a macro combustion carbon and nitrogen/protein determinator that utilizes a pure oxygen environment in a high-temperature horizontal ceramic combustion furnace designed to handle macro sample mass.

sample can be ground more easily. The cellulose-sample mix is then ground and analyzed. When cellulose powder is added, it will be necessary to convert the % nitrogen content in the mix back to % nitrogen content in the original material. When the ratio is exactly 1:1, the % nitrogen content as reported by the instrument needs to be multiplied by two.